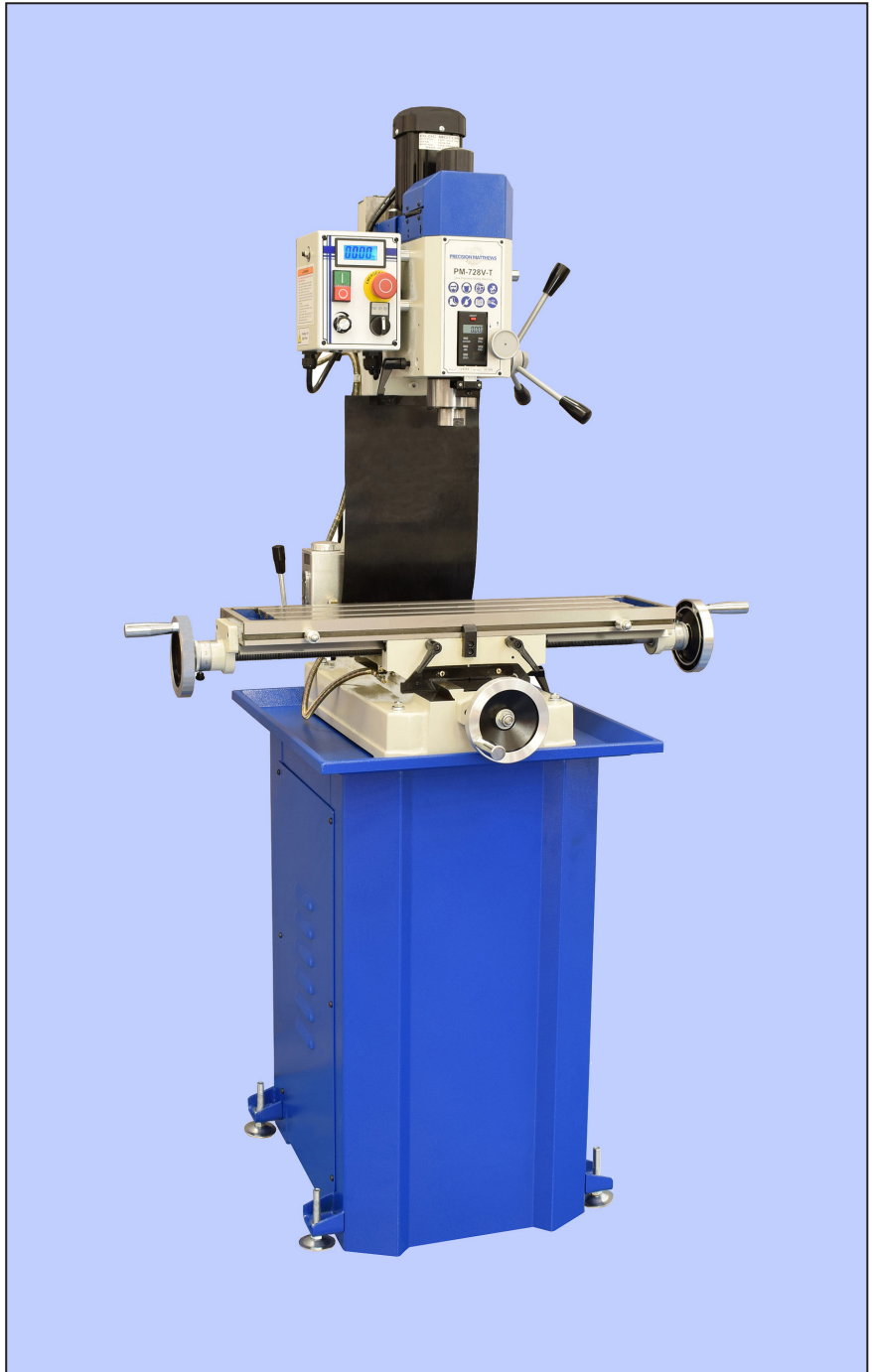


Model PM 728V-T Precision Milling Machine

Square column design, heavy cast iron construction
High weight-to-size factor: 370 lb excluding stand
1 HP (750W) brushless dc motor, 110 Vac single phase power
Quiet belt drive, no gears
Variable spindle speed from 100 to 4000 + rpm
Table size 7" x 28"
One-shot lubrication system standard
Quill DRO for precise downfeed measurement



PM-728V-T with optional stand



PM-728V-T

FAQ

! My mill doesn't run



110 Vac power connected?
GREEN button pressed?
Speed control set?
E-Stop button out? (pop it out by twisting firmly clockwise)
Circuit breaker popped?
Belt cover closed? See photo at right, item (3)

! R8 collets won't go into the spindle

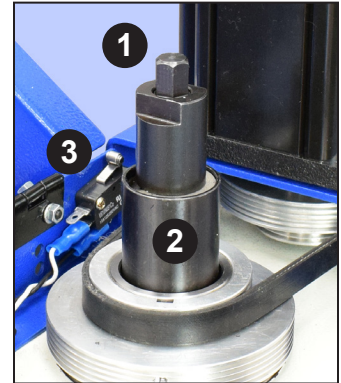


The collet locating screw could be in too far. Back it out a little.

! The control box beeps when power is switched off

No problem — this is not a fault condition

! The drawbar doesn't seem to be long enough



Install the drawbar (1) INSIDE the spindle cap (2), as here (unscrew cap, insert drawbar into spindle, replace cap)

(3) Belt cover microswitch (must close to power-up the mill)

This manual contains essential safety advice on the proper setup, operation, maintenance, and service of the PM-728V-T milling machine. Failure to read, understand and follow the manual may result in property damage or serious personal injury.

There are many alternative ways to install and use a mill. As the owner of the mill you are solely responsible for its proper installation and safe use. Consider the material contained in this manual to be advisory only. Quality Machine Tools, LLC cannot be held liable for injury or property damage during installation or use, or from negligence, improper training, machine modifications or misuse.

This manual describes PM-728V-T machines as shipped from early 2020. There may be detail differences between your specific machine and the information given here (with little or no impact on functionality). Please email us if you have questions about any aspect of the manual or your machine (see our website www.precisionmatthews.com for support contacts). Your feedback is welcomed!

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Section 1 INSTALLATION



THESE ARE THE MAIN POINTS TO WATCH OUT FOR! *But read the following pages for more information*

- Handling the mill is at least a two-person job.
- Lower the center of gravity by hand-cranking the headstock down until the spindle nose is just clear of the table.
- Lifting gear – sling, hoist or forklift – must be rated for at least 500 lb.
- The working location of the mill must allow: Full left-right travel of the table, also access to the top of the column (for Z-axis leadscrew maintenance).
- Power requirement is 110V, 60Hz, 1 ϕ , 20A circuit protection.
- Extension cord not to be used
- **Before connecting power** for the first time be sure that:
 1. The machine is on a firm footing, adequately secured to bench or stand.
 2. No chuck or collet is installed.
 3. The drawbar has been removed (see below).
 4. There are no clamps or locks on moving parts.
 5. The speed control knob is set for the lowest speed.

SETTING UP THE MILL

The PM-728V-T is shipped in two packing cases, one for the machine and tray (and optional 3-axis DRO), one for the stand, if ordered.

Removing the drawbar

1. With the table **protected by scrap material**, loosen the quill lock lever, then lower the quill.
2. Swing open the drive cover in front of the motor, Figure 1-1.
3. While holding the spindle nose with the special C-wrench (supplied), use a 17 mm wrench to unscrew and remove the spindle cap. See also Figures 3-3 and 3-4.
4. Remove the drawbar from the spindle. Re-install the spindle cap, hand-tight.

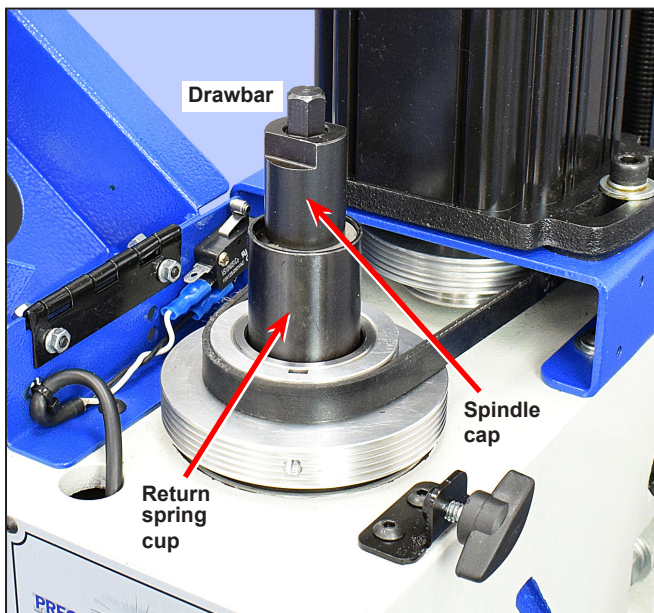


Figure 1-1 Access to the drawbar

UNCRATING & MOVING THE MILL

The following procedure makes use of an **engine hoist**, minimum weight rating 500 lb. If a hoist is not available, and you need to use manpower for lifting, see the dismantling instructions on the following page.

First, no matter what the lifting method is, prepare the bench or optional stand, with the chip tray in its working location.

Highly recommended! Bolt the bench or stand firmly to the floor. Check working clearances, Section 2.

1. If the handwheels were shipped loose, install the largest of the four at the top of the column. The three smaller handwheels are for the X-axis (2) and Y-axis (1).
2. Release the table locks, X-axis and Y-axis.
3. Release the headstock Z-axis locks.
4. Center the table (X-axis), then move the table back to the column as far as it will go (Y-axis).
5. Crank the headstock (Z-axis) down so that the spindle nose is just clear of the table. The mill's center of gravity should now be as far **down** and **back** as possible. Tighten the Z-axis lock.
6. Unscrew the four nuts securing the mill to the pallet.
7. If necessary, setup the hoist with its legs straddling the machine as follows: 1. Remove one leg from the hoist, then position the other leg over the pallet, as close to the machine base as possible. 2. Re-install the removed leg, positioning it over the pallet, likewise close to the machine base. 3. Set the hoist arm short enough so that the hook is immediately overhead the collar.
8. Run a padded sling under the headstock, as Figure 1-2.
9. Taking care not to damage the Z-axis locking handle and the electrical box, hook the sling, basket style, to the hoist's hook/chain.

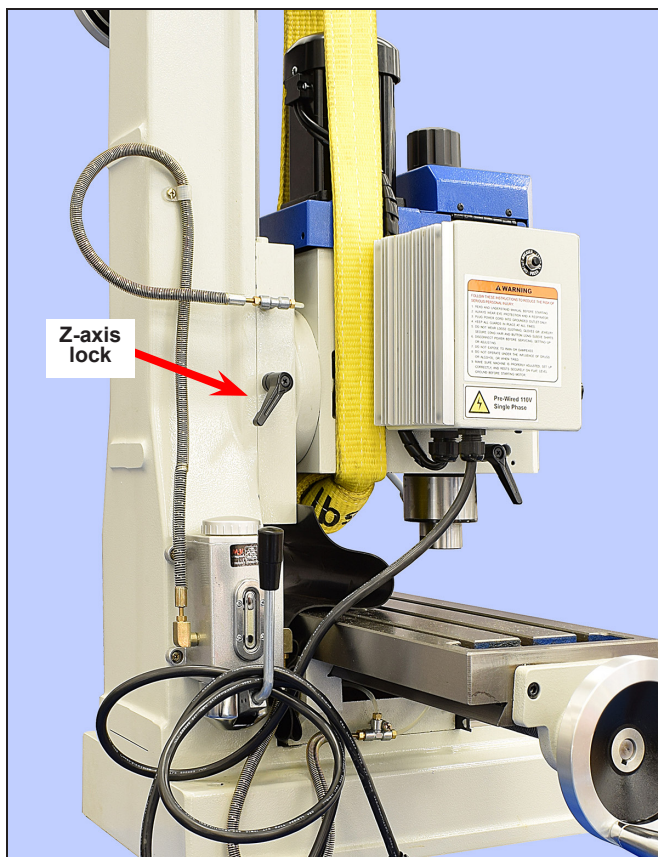


Figure 1-2 Sling position

10. Slowly lift the mill clear of the pallet.
11. Roll the mill into position over the chip tray, then lower it into place, Figure 1-3.
12. Secure the mill to the bench or stand. If this is a stand installation, use the four bolts M8 x 100 mm bolts supplied. Use plain and lock washers in all locations.



Figure 1-3 Lowering the mill into position

OPTIONAL

PARTIAL DISASSEMBLY OF THE MILL

If a hoist is not available, and the mill has to be moved by manpower, this is more manageable if the headstock and table are temporarily removed. **Not a one-person procedure.**

Table removal

1. Remove handwheels, support brackets and other components from both ends of the leadscrew. Set the parts aside in separate left-hand/right-hand containers.
2. Remove the gib from the front dovetail.
3. Slide table to one side then lift it clear, taking care not to damage the dovetails.

Headstock removal

1. Assemble a stack of 2 x 4s as Figure 1-4. Lower and lock the quill so that the spindle nose rests on the front 2 x 4 (this is for balance, not for load bearing).
2. Crank the headstock down to the point where the headstock is felt to be pressing firmly on the back 2 x 4s — **firmly**, meaning the headstock will not suddenly shift when its two attachment nuts are loosened.
3. With another person on hand to stabilize the headstock, remove the two attachment nuts, then move the table forward clear of the T-bolts.

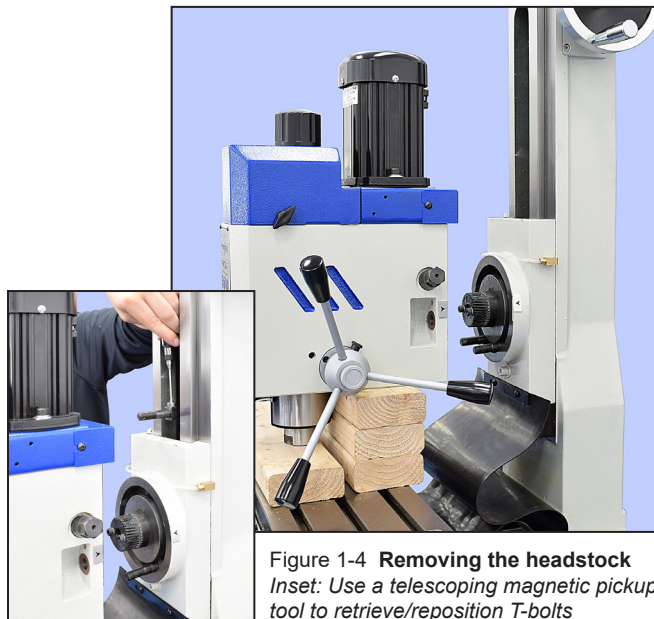


Figure 1-4 Removing the headstock
Inset: Use a telescoping magnetic pickup tool to retrieve/reposition T-bolts

Assembly and cleanup

Unfinished metal surfaces may be protected in shipping by thick grease and/or paper. Carefully remove these using a plastic paint scraper, disposable rags and a light-oil such as WD-40. Coat bright machined surfaces after cleaning with a rust preventative such as Rustick. Do not leave them bare, or rust may start quickly.

Level the mill using the table surface for reference, shimming under the tray if necessary. If the mill is on the optional stand, adjust the leveling feet. Oil the ways and leadscrews (Z-axis leadscrew excepted, inaccessible).

INITIAL CHECKS

Read Section 3 if unsure about any item in the following

1. Check that no chuck or collet is installed, drawbar removed; no clamps or locks on moving parts.
2. Turn the speed control knob fully counter-clockwise (lowest speed).
3. Open the blue motor cover. Make sure the belt is set for low speed (belt running on the larger front pulley.) If not, re-position the belt, Figure 3-2. Replace the motor cover. Make sure the spindle is free to turn.
4. Connect 110 Vac power.
5. Be sure the **E-Stop** (Emergency) button has not been pushed in (it should pop out when twisted firmly clockwise).
6. Press the green **Power** button. The power lamp and the tach display should light.
7. Select **FWD** spindle direction, then turn the speed knob a few degrees to the right. Viewed from above, the spindle should rotate clockwise.
8. Rotate the speed control knob clockwise for a speed of 300 to 400 rpm. Run the spindle at that speed for about 1 minute, then progressively increase the speed to the maximum (about 1500 rpm).
9. Check the emergency function by pressing the E-Stop button. This should disable the power circuit, stopping the spindle. You will hear a series of beeps from the electrical box once power is disconnected. This is normal.

If #9 doesn't happen, the E-stop function is defective, and needs attention - This should stop the machine when pressed.

10. Restore power by twisting the E-Stop button firmly to the right; this will cause it to pop out. You can now re-start the machine as shown starting in step 6 above.
11. Re-install the drawbar UNDER the spindle cap, Figure 1-1.

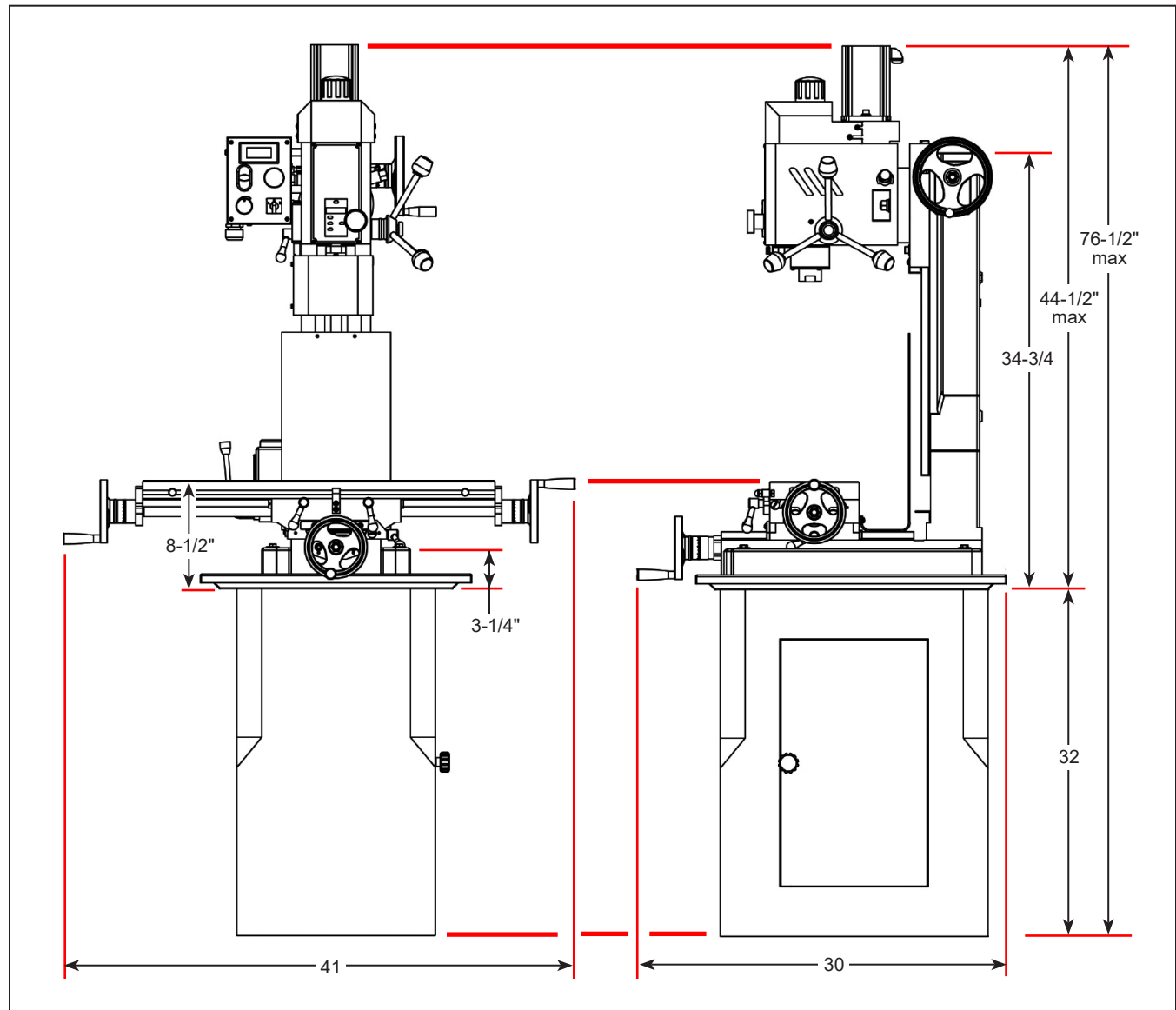
Section 2 FEATURES & SPECIFICATIONS

MODEL PM-728V-T Milling Machine

General information

The PM-728V-T is a robust “square column” mill with R8 spindle and continuously-variable spindle speed up to 4000 rpm. It is designed for day-in, day-out use in the model shop. With a weight of 370 lbs it can handle far more than the typical machine of its size. For precise control of cutter depth there is a worm-driven quill downfeed with graduated dial and built-in DRO, completely independent of headstock elevation.

The reversible spindle runs in high-quality, deep-groove ball bearings enclosed in a robust quill with coarse (drilling) and fine (milling) downfeed options. It is powered by a 1 HP (750 W) brushless dc motor. Spindle speed is continuously variable from approximately 100 to 1500 rpm, low range, and 300 to 4000 rpm, high range. This is a gearless design with two-step pulleys on motor and spindle coupled by a long-life ribbed belt. The headstock can be tilted 90° clockwise and counter-clockwise from the vertical. Precision ground dovetailed ways for table and headstock ensure smooth, precise motion in all three axes: X = left/right motion of table 19 in., Y = front/back motion of table 10 in., Z = headstock up/down, 16-1/4 in. (Installation of DRO scales on the table and headstock may limit these numbers.)



PM-728V-T dimensions

PM-728V-T SPECIFICATIONS

General

Power requirement	110V, 60Hz single phase, 20A circuit
Approximate weight	Machine only: 370 lb net, 450 lb shipping Optional stand: 100 lb net, 110 lb shipping

Dimensions

Machine height, no stand	Normal operations: 36 in. Head at max elevation: 44-1/2 in.
Machine height, mounted on stand	Normal operations: 67-1/2 in. Head at max elevation: 76-1/2 in.
Stand dimensions	Height, floor to chip pan surface: 31-1/2 in. Chip pan: 21-1/2 in. W x 24-3/4 in. D Footprint: 21 in. W x 20-1/2 in. D
Floor space required	Width, full left-right travel of table: 62 in. Depth, Y-axis handle tip to back of chip pan: 30 in.

Table

Table size	7 x 28 in.	
Front-back travel, Y-axis	With DRO With full way-support: 7-3/4 in. Between hard stops: 9-1/2 in.	No DRO 8-1/2 in. 10 in.
Left-right travel, X-axis	With full way-support: 17-3/4 in. Between hard stops: 19 in.	
Leadscrew pitch, both axes	10 TPI (0.1 in. per turn)	
Handwheel dials, both axes	0.001 in. graduations	
T-slots (3)	Width: 12 mm (use PM 1/2 in. clamp kit) Between Slots: 55 mm (approx. 2-5/32 in.)	
Maximum load, centered	300 lb	

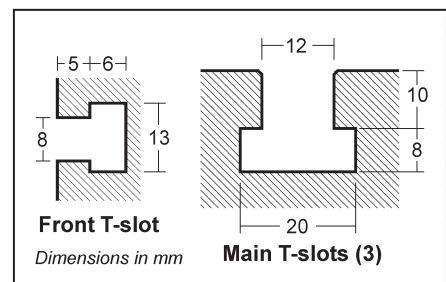
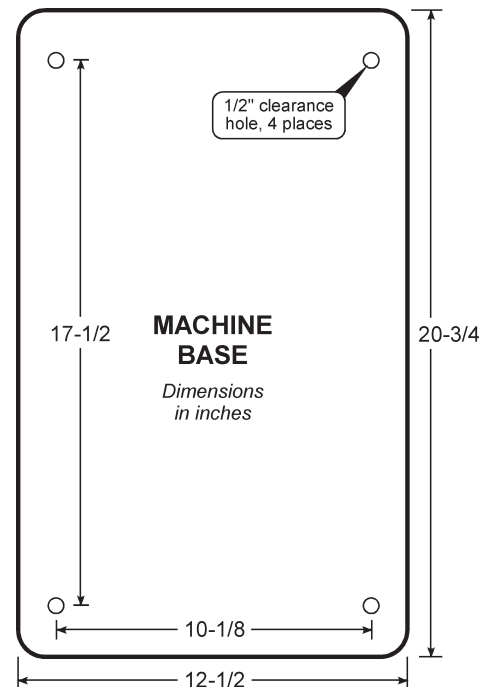
Motor & Headstock

Motor	1 HP brushless dc, variable speed
Spindle speed	Continuously variable, 100 to 4000 rpm in two ranges
Spindle dimensions	Internal taper: R8 Drawbar: 7/16-20, 11 mm hex wrench Top end splines (6): 22 mm OD
Quill (spindle) travel	3 in.
Spindle nose to table	Zero to 16-1/4 in.
Spindle centerline to front face of column	8-3/4 in.
Z-axis leadscrew pitch	10 TPI, 0.001 in. dial graduations
Headstock vertical travel	16-1/4 in.
Headstock left-right tilt	90 degrees - zero - 90 degrees

Typical cutting capacities in steel

Drilling 3/4 in., End milling 1 in., Face milling (with multi-tip tool) 3 in.

Special accessory supplied:
Spindle C-wrench



T-slot dimensions



Everyday precautions

- This machine is designed for milling and drilling operations by experienced users familiar with metal-working hazards.
- Untrained or unsupervised operators risk serious injury.
- Wear ANSI-approved full-face or eye protection at all times when using the machine (everyday eyeglasses are not reliable protection against flying particles).
- Wear proper apparel and non-slip footwear – be sure to prevent hair, clothing or jewelry from becoming entangled in moving parts. Gloves – including tight-fitting disposables – can be hazardous!
- Be sure the work area is properly lit.
- Never leave chuck keys, wrenches or other loose tools on the machine.
- Be sure the workpiece and machine ways are secure before commencing milling or drilling – hold-downs and/or vise fully tightened, X-Y-Z axes locked, cutting tool secured.
- Use moderation: **light** cuts, **low** spindle speeds and **slow** table motion give better, safer results than “hogging”.
- Don’t try to stop a moving spindle by hand – allow it to stop on its own.
- Disconnect 110V power from the mill before maintenance operations such as oiling or adjustments.
- Maintain the machine with care – check lubrication and adjustments daily before use.
- Clean the machine routinely – remove chips by brush or vacuum, not compressed air (which can force debris into the ways).

***No list of precautions can cover everything.
You cannot be too careful!***

Section 3 USING THE MILL

HEADSTOCK CONTROLS



Before doing anything, check the installation instructions in Section 1

1. Make sure the direction switch is set to **OFF**. Connect the mill to a 110Vac outlet.
2. Press and release the green Power **ON** button to energize the control circuit; the tachometer should light. This is a self-latching circuit – when the **ON** button is released, a contactor in the electrical box maintains power until released by the red **OFF** button (also a momentary switch).
3. The large red E-stop button is in series with the **OFF** button. Like the **OFF** button it de-energizes the control circuit completely, but it should be used only for emergency disconnect. Once the E-stop button is pushed in, it stays in until twisted **firmly clockwise** to release.
4. The spindle motor is controlled by a three position switch, Forward/Stop/Reverse, and a continuously-variable speed control knob.

FWD = Forward (clockwise, looking down, used for most milling and drilling)

OFF = Stop

REV = Reverse (counter-clockwise, looking down)

Always use the **Direction Switch**, not the Power buttons, to turn the spindle on and off, except during an emergency

Use the **Power Buttons** only to power-up and power-down the mill.

When powering-down, it is normal to hear a series of beeps from the electrical box.

SPINDLE SPEEDS

The PM-728V-T is a belt-driven machine with two speed ranges, (L) 100-1500 rpm and (H) 300-4000 rpm.

To select a speed range, disconnect power, then open the top cover. Loosen the socket head screws on each side of the motor, then swing the motor forward to free the belt, Figure 3-2. Make sure that the ribbed belt is properly engaged with the selected pair of grooved pulleys, then re-tighten. Before powering up, rotate the spindle by hand to check tracking and tightness of the belt. Do not over-tighten – aim for $\pm 1/4$ " slack between the motor and spindle pulleys.

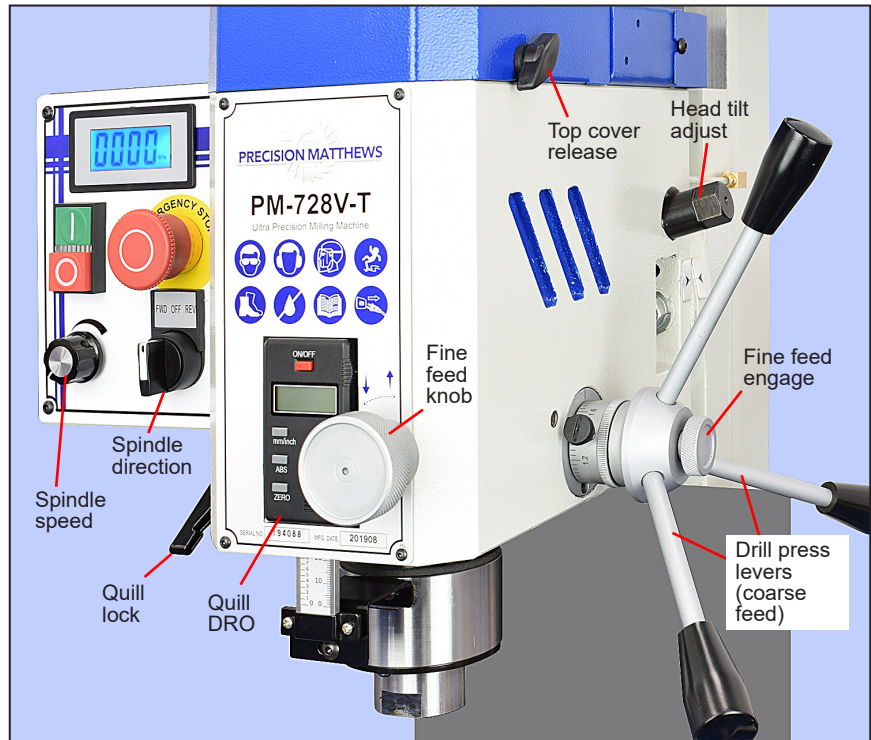


Figure 3-1 Headstock controls



Figure 3-2 Belt adjustment



Excessive cutter noise, chatter, poor finish and tool wear are often the result of too high a feed rate, and/or too high a spindle speed. If unsure, go slow!

INSTALLING AND REMOVING TOOLING

The spindle and drawbar are designed for R-8 taper collets, drill chucks and other arbors with the standard 7/16"-20 internal thread.

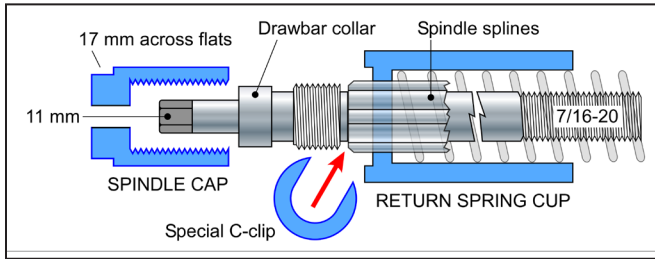


Figure 3-3 Spindle schematic

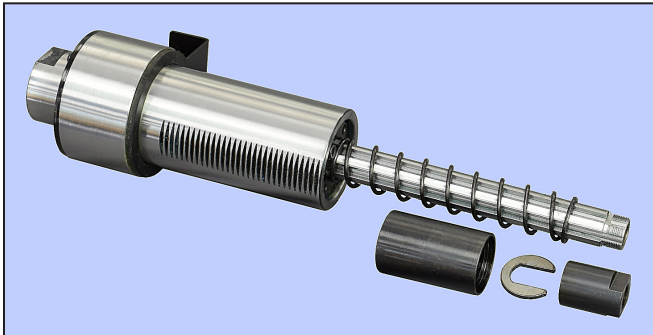


Figure 3-4 Spindle disassembled (drawbar omitted)

Two tools are required to install or remove R8 tooling: an 11 mm wrench for the square drawbar nut, and the supplied C-wrench which engages in flats at the bottom end of the spindle.



R8 tooling is located in the spindle bore by an M4 x 6 mm long set screw. If it is difficult or impossible to insert the R8 device, chances are the set screw is in too far. Rotate the spindle by hand to expose the screw, Figure 3-6, then back it out a fraction of a turn using a 2 mm hex wrench.

Hand rotate the spindle again to check that the screw clears the inside surface of the quill.

Installing R8 tooling

Install the R-8 device, then hand-thread the drawbar into it until the drawbar collar bottoms on the splined spindle (on the machine itself this action is concealed by the spindle cap, Figure 3-3). Fully tighten the drawbar with an 11 mm wrench, while at the same time holding the spindle stationary with the special C-wrench, page 7. [Do **NOT** try to hold the spindle using the flats on the spindle cap.]

Removing R8 tooling

Protect the table, vise or workpiece under the spindle with rags or scrap wood. **Why?** Because they can easily be damaged by falling tools and drill chucks. The cutting tool itself can also be damaged in the same way.

Lock the spindle with the C-wrench, loosen the drawbar one turn or less, just enough to unseat the taper, then tap the top of the drawbar with a brass or dead-blow hammer to break the taper seal. Unscrew the drawbar with one hand while supporting the R-8 device with the other hand.

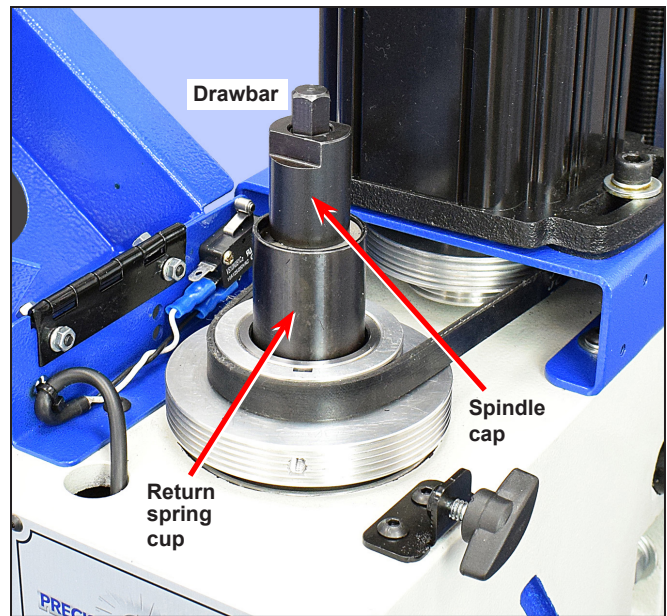


Figure 3-5 Two-step belt drive
The drawbar collar, Figure 3-2, must be **UNDER** the spindle cap, as shown



Figure 3-6 Collet set screw

MOVING THE TABLE & HEADSTOCK

Conventionally, left-right movement of the table is said to be along the X-axis (also called “longitudinal travel” or “traversing”). Leadscrew handwheels are provided at both ends of the table, Figure 3-7. Front-to-back movement is along the Y-axis, sometimes called “cross travel”. The Y axis leadscrew has a single handwheel at the front, Figure 3-8.

Headstock motion is in the Z-axis, in line with the vertical column. The headstock is raised and lowered by a handwheel at top right of the column, Figure 3-9.



Figure 3-7 X-axis handwheel & dial (right hand)

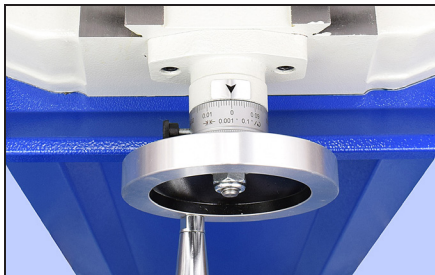


Figure 3-8 Y-axis handwheel & dial

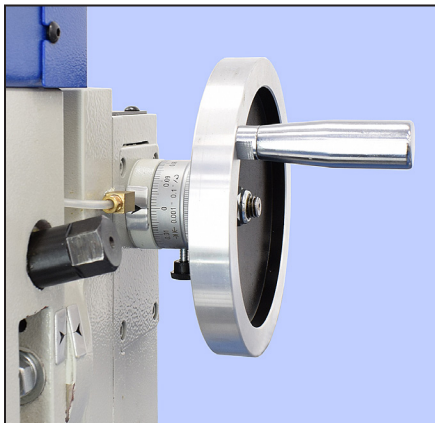


Figure 3-9 Z-axis handwheel & dial

Each axis has a leadscrew with handwheel and graduated dial with 0.001” divisions, 0.1” per revolution, Figures 3-7 to 3-9. If the mill is not equipped with digital readouts (DROs), the table and headstock can be accurately positioned by counting whole turns and divisions, keeping **leadscrew backlash** in mind. This means that motion must always be in the same direction up to the point of reference, then on to the desired

location, see “Positioning by Counting X-Y Divisions”, later in this section.

LOCKING THE AXES

Before machining a workpiece it is usually necessary to position the table precisely, then lock either the X or the Y axis, sometimes both (for drilling and similar operations). You can also use the lock levers to apply a **light** drag to the axis in motion. This can help reduce chattering (better surface finish) and also lessen the chance of overshooting inadvertently. To reduce wear, free the levers once the operation is completed.

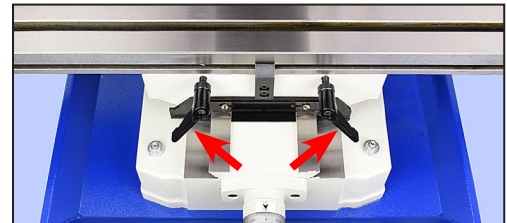


Figure 3-10 X-axis locks

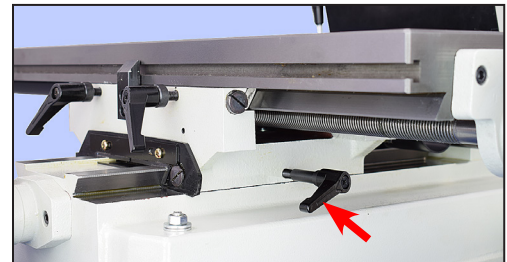


Figure 3-11 Y-axis lock

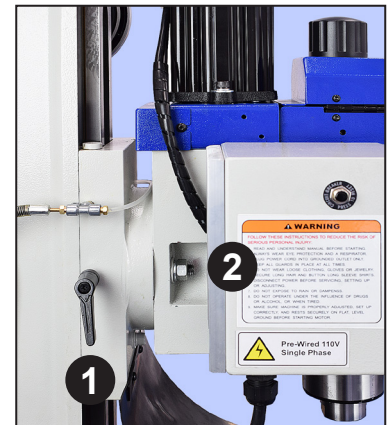


Figure 3-12 Z-axis lock (1)

Also shown here (2) is one of two headstock attachment nuts.

When possible, operations calling for precise depth control (such as milling) should be done with the headstock locked, also with the quill fully retracted into the headstock and locked.

QUILL DOWNFEED

The quill is controlled in two different ways, **coarse** and **fine**.

For drilling operations, coarse feed, the milling machine operates like a standard drill press with a 3-lever hub. Lever action lowers or raises the quill in the usual way by rack and pinion. Return action is assisted by a compression spring within the quill and spindle assembly, Figures 3-3 and 3-4.

For milling operations the lever hub is not usually rotated by lever action. Instead it is driven through worm gears turned by the fine control knob, Figure 3-13 (2). This allows the quill to be driven precisely to any desired position. The fine control knob, because it drives through a worm, cannot be back-driven by return-spring action on the quill (in other words, it stays where it's put). For milling operations the quill should, when possible, be fully retracted, then locked by the lever on the left of the headstock, Figure 3-1.

Coarse feed (Figure 3-13)

For drilling operations, loosen knob (4), allowing the lever hub (1) to rotate independently of sleeve (3).

Fine feed (Figure 3-13)

For milling operations calling for precise, repeatable control of tool depth, tighten knob (4) to engage hub (1) with the internal taper on sleeve (3). Tighten the Z-axis lock, Figure 3-12.

Rotate the fine control knob (2) to raise or lower the quill. Lower the quill by rotating the fine control knob clockwise, positioning it precisely either by counting divisions on the graduated dial, or by reference to the quill digital readout (DRO), Figure 3-1. Use the locking lever left of the headstock to hold the quill firmly in position.

! If you are counting downfeed divisions be aware of backlash in the worm drive.

The quill DRO – which has no backlash issues – offers a less laborious way of setting tool height, but bear in mind that the quill is **spring-loaded**.

This calls for care when releasing the quill locking lever. If the fine control knob has been allowed to disengage (backed off counter clockwise), the quill may jump up by 0.01" or more. To avoid this, make sure the fine control has been turned **clockwise** to apply downward pressure on the quill before the locking lever is released.

QUILL DRO

The quill DRO is in metric mode when switched on. Press the mm/in button to display inches.

Replace the battery by removing the small molded cover on the face of the DRO unit (align the dots). Check the type number and voltage of the installed battery. Replace with an equivalent (LR44 or Equivalent) available from local retailers.



Switch off the DRO when not in use!



Figure 3-13 Quill downfeed controls

The lever hub (1) is connected at all times to the quill pinion, which engages a rack on the back side of the quill. The fine control knob (2) drives sleeve (3) through a worm gear. If clamp knob (4) is unscrewed, both (2) and (3) rotate freely, doing nothing to the quill. Fine feed is engaged by tightening knob (4) to clamp (3) and (1) together. The depth dial, graduated in 40 mil (0.04") increments, is locked to sleeve (3) by thumbscrew (5).

Worm shaft (6) enables precise adjustment of the headstock tilt angle.



Figure 3-14 Quill depth dial

POSITIONING BY COUNTING X / Y DIVISIONS

For all spindle positioning operations avoid using the quill lock. When possible, retract the quill fully, then adjust the headstock elevation instead.

Why? On practically all vertical mills, including the heavier knee mills, locking the quill may offset the spindle by a few thousandths of an inch. For milling operations this is not a problem provided edge "finding" **and** subsequent machining are **both done** with the quill retracted and locked.

Drilling, on the other hand, is quite different. If the edge of the workpiece has been "found" with the quill locked, this may affect placement of holes drilled thereafter. Instead, do the finding by lowering the headstock, or lower the quill with the fine downfeed control — no locking in either case.

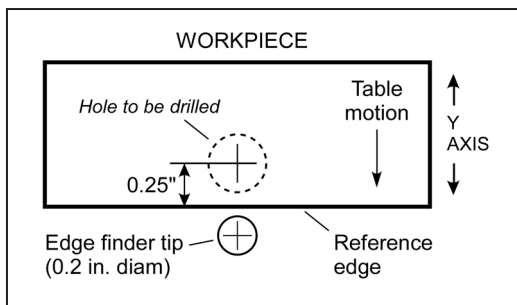


Figure 3-15 Workpiece positioning example

In this illustration a hole is to be drilled exactly 0.25" on the Y-axis relative to the front edge of a workpiece in a vise, or otherwise clamped to the table, Figure 3-15.

1. Install an edge-finder in collet or chuck (a tip diameter of 0.2" is assumed).
2. Lock the X-axis (optional).
3. If the reference edge is already to the back the spindle centerline, do nothing; if not, rotate the Y-axis handwheel clockwise to send the workpiece backwards (toward the column).
4. Engage the fine downfeed, Figure 3-13.
5. With the spindle running, lower the quill as necessary using the fine downfeed control, then bring the table forward (counter-clockwise), stopping at the point where the edge-finder just makes contact (the tip jumps out of line). Stop the spindle.
6. While holding the Y-axis handwheel to prevent rotation, zero the Y dial.
7. Raise the quill, then rotate the handwheel one exact full turn counter-clockwise (0.1") to bring the reference edge to the spindle centerline.
8. Rotate the handwheel 2-1/2 turns counter-clockwise to bring 50 on the dial opposite the datum; the spindle is now precisely 0.25" to the back of the reference edge.

TAPPING OPERATIONS

When threading a drilled hole it is essential to align the threading tap properly in the bore. The mill is often used for this purpose, ideally with a dedicated (non-slip) tap holder or, for production work, an auto-reverse tapping attachment, e.g., Tapmatic.

A drill chuck can be used instead for sizes up to (say) M6 or 1/4", beyond which the chuck may not grip tightly enough to avoid slippage. Tapping can be done under power, or by hand turning the chuck.

For either method, it is essential to use a tapping fluid. Any cutting oil is better than none, but most users find Castrol's Moly Dee the most reliable for threading in steel.

If power tapping, bear in mind that the spindle does not stop instantaneously, so be careful tapping blind holes. **Free the quill locking lever.** Start with the lowest spindle speed. Counteract the effect of the quill's return spring by applying gentle downward pressure on the quill while feeding in the tap. (This is to reduce lifting force on the workpiece, which tends to pull the workpiece out of the chuck.) For easier tapping it may be helpful to experiment with a larger hole than specified in the

usual tap drill charts. Typically, a 10% reduction in drill size below nominal causes no real difference in holding power or thread integrity under load.

TILTING THE HEADSTOCK

In routine operations the user relies on squareness of the spindle relative to both axes of the table. Front-to-back squareness is set at the factory, and is not adjustable by everyday methods. In the other plane, the headstock can be set to any angle up to 90 degrees either side of the normal vertical position. Because re-establishing true vertical (tramming) on any mill is a time consuming process, most machinists look first for other ways of handling a project instead of tilting the head.

The headstock is secured by two nuts spaced on either side, Figure 3-12. The headstock is top-heavy, and may swing suddenly to either side unless a helper is on hand to restrain it. Testing for movability as you go, carefully loosen the nuts by degrees. Be especially careful if the head has not been moved before — the paint seal may let go without warning. (First-time tilting may also call for unusual effort on the wrench.)

Set the headstock to the desired tilt using a digital angle indicator such as Figure 3-16. Insert a length of bar stock, ideally ground, in a collet of known accuracy (check for runout at the tip). Angle indicators like this are typically good within $\pm 0.2^\circ$. If the project calls for greater accuracy a more accurate means of angle measurement will be needed.

Fine adjustment of tilt angle is made easier by a **worm shaft & worm wheel** combination. The worm shaft, Figure 3-13 (6), engages a worm wheel secured to the headstock casting, Figure 3-17 inset. Use a 21 mm wrench to turn the worm shaft.



Figure 3-16 Headstock tilt angle measurement
Use the indicator's relative mode to measure the angle between the spindle and the surface of the workpiece.



Figure 3-17 Headstock worm wheel

TRAMMING THE HEADSTOCK

As shipped, the mill is set to zero tilt, squared accurately enough for initial test drillings, etc., out of the crate. For more demanding project work thereafter, the spindle needs to be set at precisely 90 degrees relative to the table, in other words trammed. “Out of tram” may show up as an offset of a few thousandths between entry and exit of a deep hole, or as a scalloped effect when surfacing a workpiece with a large-radius fly cutter, greatly exaggerated in Figure 3-18.

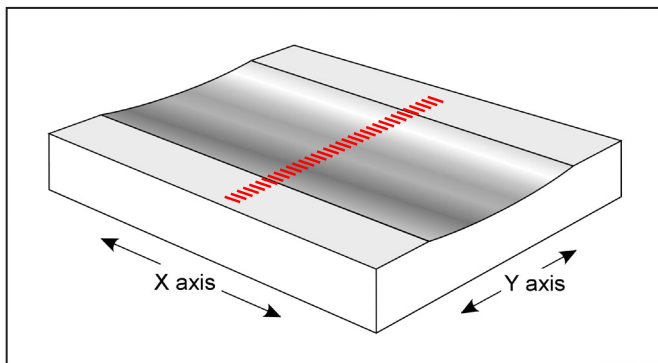


Figure 3-18 Head tilt affects surface flatness

This is the effect, much exaggerated, if the head is tilted minutely out of square when milling a surface with a large diameter cutter. In the other axis the scalloping effect would be at right angles (hashed red line) if the head is tilted forward or back, and the table is moved in the Y-axis.

Tramming is done by fine-tuning the headstock tilt angle. Check the tram by attaching a dial indicator to some form of “sweepable” holder installed in the spindle. The aim is to adjust tilt for the same reading on either side of the X axis. The longer the radius arm, the greater the sensitivity.

Figure 3-19 shows a typical shop-made holder; it has a threaded arbor allowing the choice of two radius arms, 6 and 10 inches measured from spindle centerline to indicator tip. A collet is used to hold the arbor, in this example 5/8" diameter. The dimensions are arbitrary, but note that the indicator must be firmly attached, with the arm rock-solid relative to the indicator spring force (which can be considerable on plunger-type indicators).

A suggested procedure for establishing tram:

1. Disconnect power.
2. Install the dial indicator.
3. If the headstock has been tilted, reset it to the approximate zero degree position on the tilt scale, then tighten the two nuts enough to avoid unexpected headstock movement.
4. Remove the vise, if installed, and clean the table surface. If there are noticeable grooves or dings, flatten the surface with a diamond lap or fine-grit stone.
5. Set a 1-2-3 block (or other precision-ground block) on the table under the indicator probe.
6. Switch on the quill DRO.
7. Using the fine downfeed lower the spindle to give an indicator reading of about half-scale.
8. Note the dial indicator **and** DRO readings, then back off the fine downfeed at least a couple of turns to avoid collision when sweeping.
9. Reposition the 1-2-3 block to the opposite location on the table.

10. Swing the indicator holder to the new location, then lower the spindle – fine downfeed again – to give the same dial indicator reading as in step (8).

If the headstock is perfectly trammed – highly unlikely at the first shot – the DRO reading should be as in step (8). If not, loosen the nuts just enough to allow the headstock to allow very small adjustments — fractions of a degree — by turning the worm shaft, Figure 3-13 (6). Re-tighten the nuts.

Repeat steps (7) through (10) until satisfied with the tram, tightening the nuts as you go. This will likely call for several iterations. There is no “right” tram; the acceptable difference in side-to-side readings depends on project specs. As a starting point, aim for ± 0.002 " with a sweep radius of 5 or 6 inches.

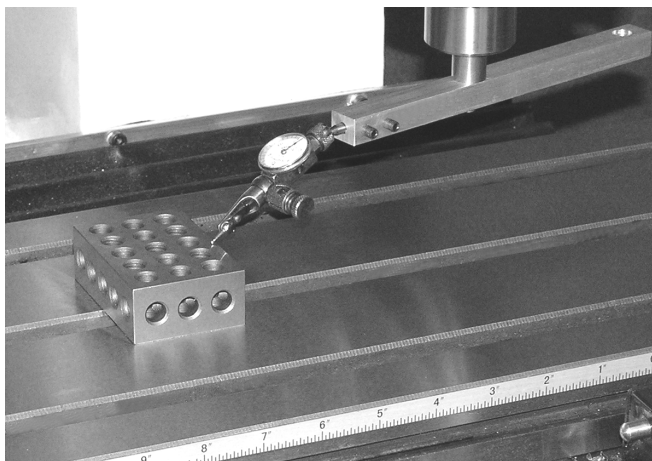


Figure 3-19 Shop-made indicator holder

! Tramming calls for patience! Expect to tighten and re-check several times (simply tightening the headstock attachment nuts can itself affect the tram)

A similar procedure may be used to check tram in the Y-axis, front to back. Tram error in the Y-axis may show up as a scalloping effect when fly cutting a nominally flat surface, Figure 3-18, red hashed line. Y-axis tram is established in manufacture, and should be adequate for most purposes.

If more precise tram is called for, it can be adjusted by sandwiching a metal shim between the headstock and its sliding base (saddle) on the column. It is more likely that the headstock is nodding forward rather than leaning backward, so start with (say) a 1 mil (0.001") shim in the bottom quadrant of the machined mating surfaces between headstock and saddle. This is a temporary fix that may not be satisfactory if the headstock is subsequently rotated.

! In all bench mills there is a tendency for Y-axis tram to vary minutely as the headstock elevation is changed — select the “most used zone” when shimming

INSTALLING & INDICATING A VISE

For routine milling operations the workpiece is held in a precision vise. For the PM-728V-T a 4" vise is most suitable.

"Indicating" means checking the alignment of the fixed (back) vise jaw relative to the axis of table motion.

Install the T-bolts and align the vise by eye. With one of the clamp nuts snug, but not tight, tighten the other one just short of fully-tight (but tight enough so the vise won't budge without a definite tap from a dead-blow mallet).

A typical setup for indicating is shown in Figure 3-20. There is no spindle lock, but you need to **make sure that the spindle does not rotate** throughout the procedure — it helps if the low spindle speed is selected.

Set the indicator tip against the upper edge of a precision reference bar or, if not available, use the front face of the fixed jaw of the vise instead (check for dings, hone if necessary). Adjust the Y-axis to pre-load the indicator to mid range at the tightly-clamped side of the vise, then lock the Y-axis.

Note the indicator reading, then watch the indicator as you traverse the table slowly toward the loosely clamped side — **watch for any sign of spindle rotation**. Ideally, there should be no discrepancy between the indicator readings at the two ends — unlikely at the first attempt. Return the table to the starting point, then repeat the process, tapping the vise in as you go. Repeat the process as often as necessary for the desired accuracy, progressively tightening the "looser" nut. Now fully tighten both nuts, and re-check again (tightening a nut can itself introduce significant error). An established routine like this — tight to loose — can save a lot of time.

Most users aim for an end-to-end difference of not more than ± 0.001 " over the width of the vise jaw.

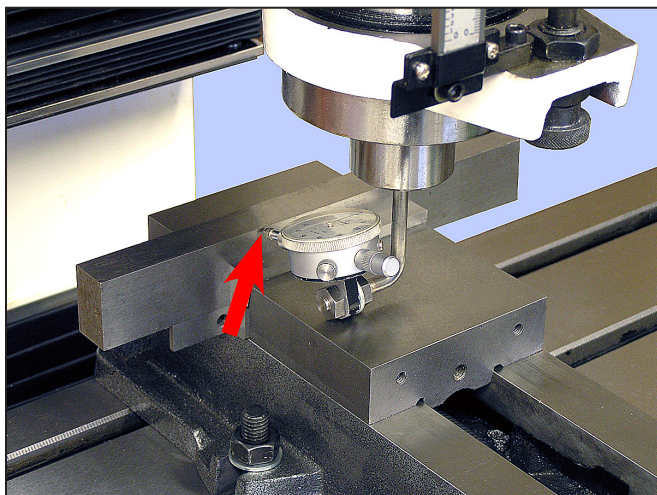


Figure 3-20 **Indicating the vise**

The tip of a standard dial indicator, arrowed, rides along the side face of a ground reference bar (or the front face of the back jaw).

WISE KEYS

Most precision vises come with key slots on the underside machined exactly parallel to the fixed jaw. Key slots, Figure 3-21, can be a great time saver. Properly installed they allow the vise to be removed and replaced routinely, accurately enough for general machining **without the need for indicating every time**.

Most 4" vises have either 14 mm or 16 mm slots, calling for shop-made T-shape adapter keys as Figure 3-22. It is well worth the effort to make these precisely. Aim for a snug fit in both vise and table, but not so tight that it takes more than a small amount of effort to lift the vise clear. Case hardening is recommended, with final fitting using a fine stone or diamond stone.

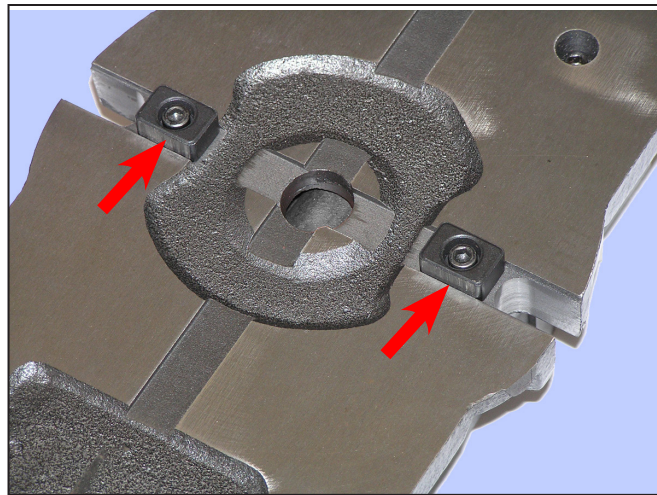


Figure 3-21 **Vise keys installed on X-axis**
On most vises the keys can also be installed on the long axis.

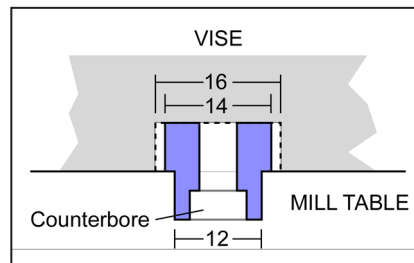


Figure 3-22 **Shop-made vise key**
Dimensions in millimeters

Section 4 MAINTENANCE



Unplug the 110V power cord before any maintenance operation!



Remove all machining debris and foreign objects before lubricating ANYTHING! If need be, any oil is better than no oil – but use the recommended lubricants when you can.

RECOMMENDED LUBRICANTS

One-shot oiler: ISO 68 way oil, such as Mobil Vactra No. 2, or equivalent

Visible gears such as quill rack and pinion, Z-axis bevel gears: light general purpose grease, NLGI No. 2, or equivalent

X, Y and Z leadscrews: ISO 68 way oil, Vactra No. 2, or equivalent

General lubrication of parts not one-shot oiled: General purpose ISO 68 way oil

GENERAL OILING

Assuming a clean environment – no abrasive particles or machining debris – lack of proper lubrication is the main cause of premature wear. There should be a small amount of seepage of oil from the mating surfaces lubricated by the one-shot oiler, namely the X, Y and Z dovetails. Be concerned if no seepage is visible.

A high-pressure air line can force sharp particles into the gaps between machine ways, and is not recommended for removing debris. Brushing off with a disposable paint brush is preferred.

Operate the one-shot oiler every few hours of operation. Use a dedicated short-bristle brush to apply oil to the leadscrews, and to the visible portions of the quill rack and pinion.

GIB ADJUSTMENT

Gibs on the X, Y and Z axes control the fit of the mating dovetailed surfaces. They are gently-tapered lengths of ground cast iron located by opposing screws at each end. Adjusting them is a trial and error process that takes time and patience. Aim for the best compromise between rigidity and reasonably free ta-

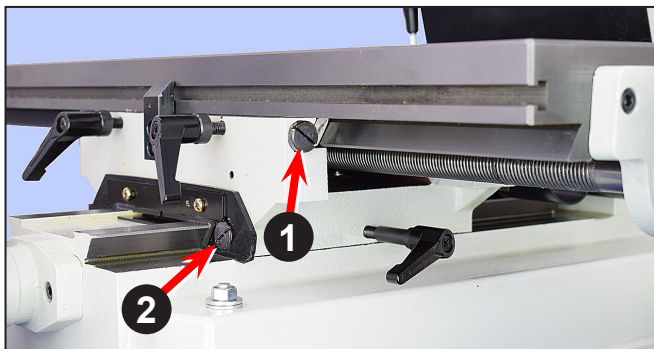


Figure 4-1 Gib adjustment, X and Y axes

The left adjustment screw for the X axis is in a similar location to (1) on the left side of the saddle casting. The back adjustment screw for the Y axis gib (2) is under the solid rubber way cover behind the table.

ble movement. Too tight means accelerated wear on the ways and leadscrews. Too free means workpiece instability, inaccuracies and chatter.

Both screw heads must be tight against the gib ends. If you loosen one, tighten the other. Remove the way covers for access to the back of the Y gib and bottom of the Z gib.

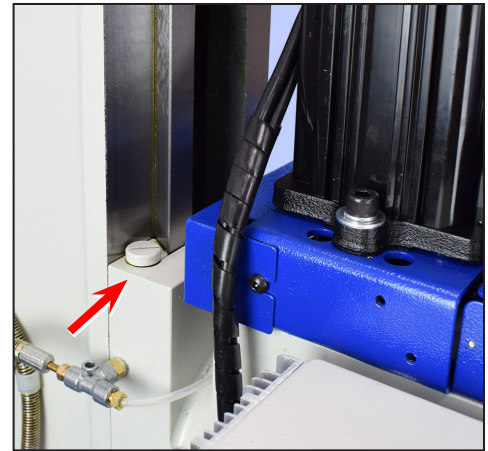


Figure 4-2 Z-axis gib adjustment, upper screw
The lower screw is under the solid rubber way cover.

LEADSCREW BACKLASH CORRECTION

When alternating between clockwise and counter clockwise rotation of the X or Y leadscrews, the handwheel moves freely a few degrees but the table stays put. This is backlash, a feature of all leadscrews other than the precision type found on CNC machines. The acceptable amount of lost motion depends on the user, but between 0.005" and 0.010" is generally a good compromise. Smaller numbers are possible, but overdoing it can lead to premature wear of leadscrew and nut.

Excessive backlash can be corrected by compressing the leadscrew split nut. For the X-axis this is done by tightening the socket head screw in Figure 4-3. Use a long-handled 4 mm hex wrench, or (better) a multi-tool with a 4 mm insert.

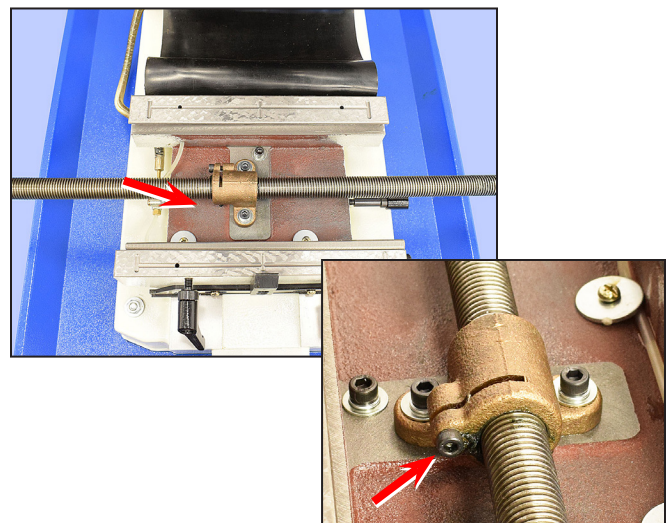


Figure 4-3 Table (X-axis) leadscrew nut adjustment
Table removed for visibility. The screw is accessible from the left side with a long-handled 4 mm hex wrench. Also seen in this photo are machined oil grooves fed by the one-shot oiler.

The corresponding adjustment for the Y-axis is shown in Figure 4-4.

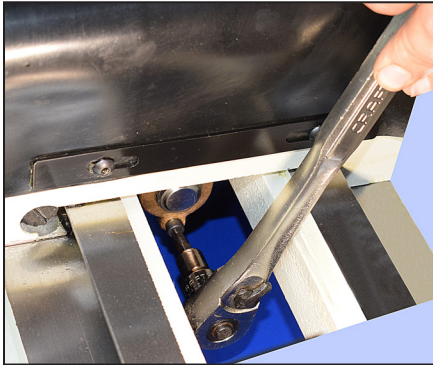


Figure 4-4 **Y-axis leadscrew nut adjustment**
Use a ratcheting wrench with a 4 mm hex insert.

For access to the leadscrew nut, remove the two screws securing the flange casting at the front. Unscrew the leadscrew, then slide the saddle/table assembly forward as in Figure 4-5.

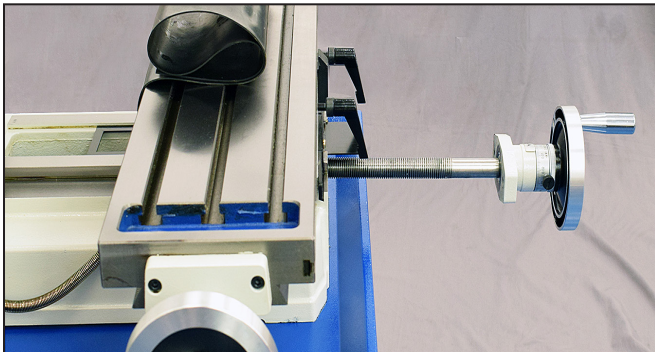


Figure 4-5 **Withdrawing the Y-axis leadscrew**

DOWNFEED RETURN SPRING

The quill should automatically retract when the coarse downfeed levers are released following a drilling operation. If it does not, check for binding in the quill lock. The return spring, Figure 4-7, is held by a spring cup which is locked to the spindle by a special C-clip beneath the spindle cap, Figure 4-6. Spring force is not adjustable.

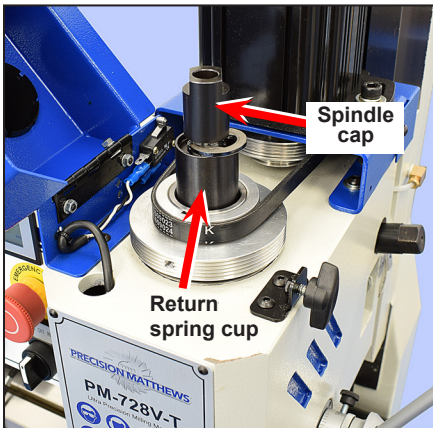


Figure 4-6 **Removing the special C-clip**

SERVICING QUILL & SPINDLE

In the normal use the quill assembly needs only oiling on its sliding surface. The spindle runs on pre-lubricated deep-groove ball bearings and needs no routine attention. If the bearings need to be serviced or replaced, remove the quill/spindle assembly as follows:



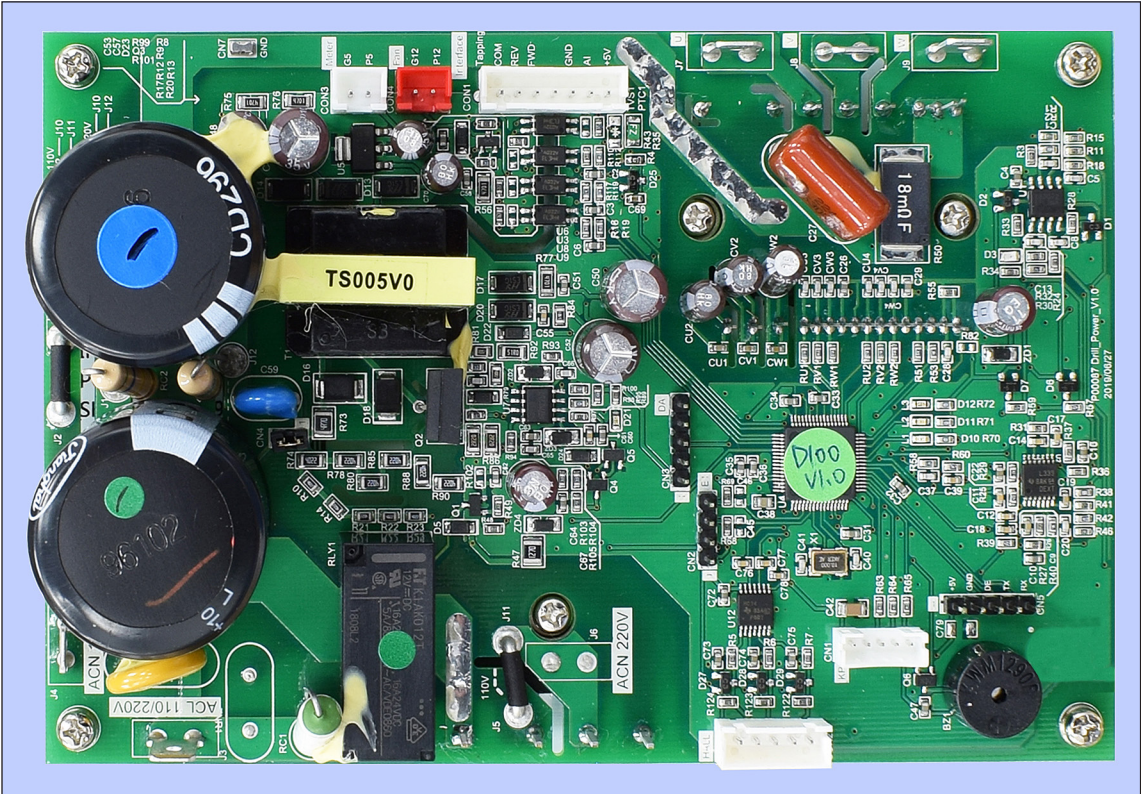
IMPORTANT: Use wood blocks or other means to **protect the table**, and to prevent **unexpected downward movement** of the quill assembly.

1. Remove any installed R8 device from the spindle.
2. Lock the spindle with the C-wrench, then unscrew the spindle cap (17 mm flats) from the spindle.
3. Remove the drawbar.
4. Press down on the return spring cup while removing the C-Clip, Figure 4-6.
5. Remove the return spring, Figure 4-7.
6. Using a 2.5 mm hex key remove the two button head screws securing the DRO scale and stand-off block to the quill assembly.
7. Loosen the quill lock lever, then remove the quill assembly from the headstock.



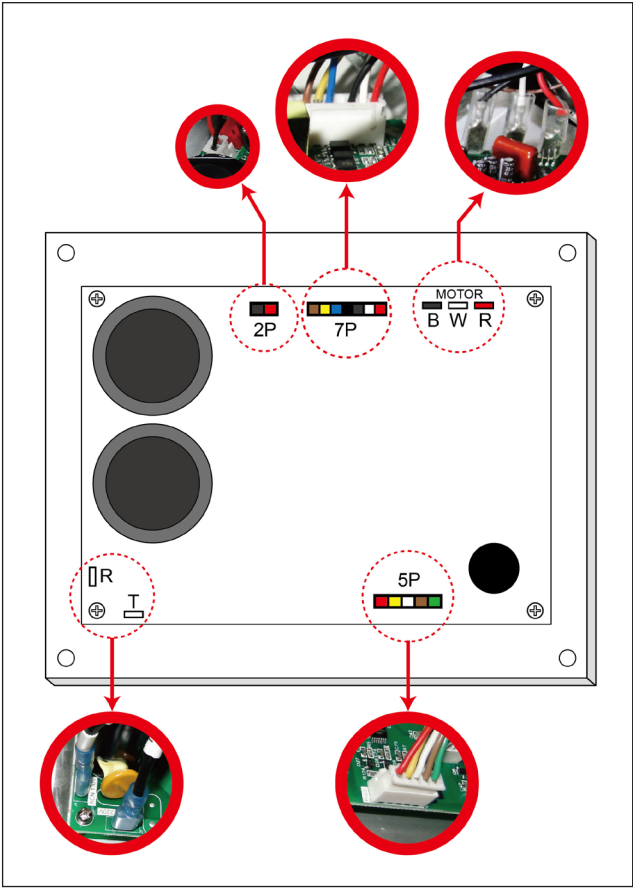
Figure 4-7 **Quill return spring**

Section 5 PARTS



There may be details between this representation and the machine as

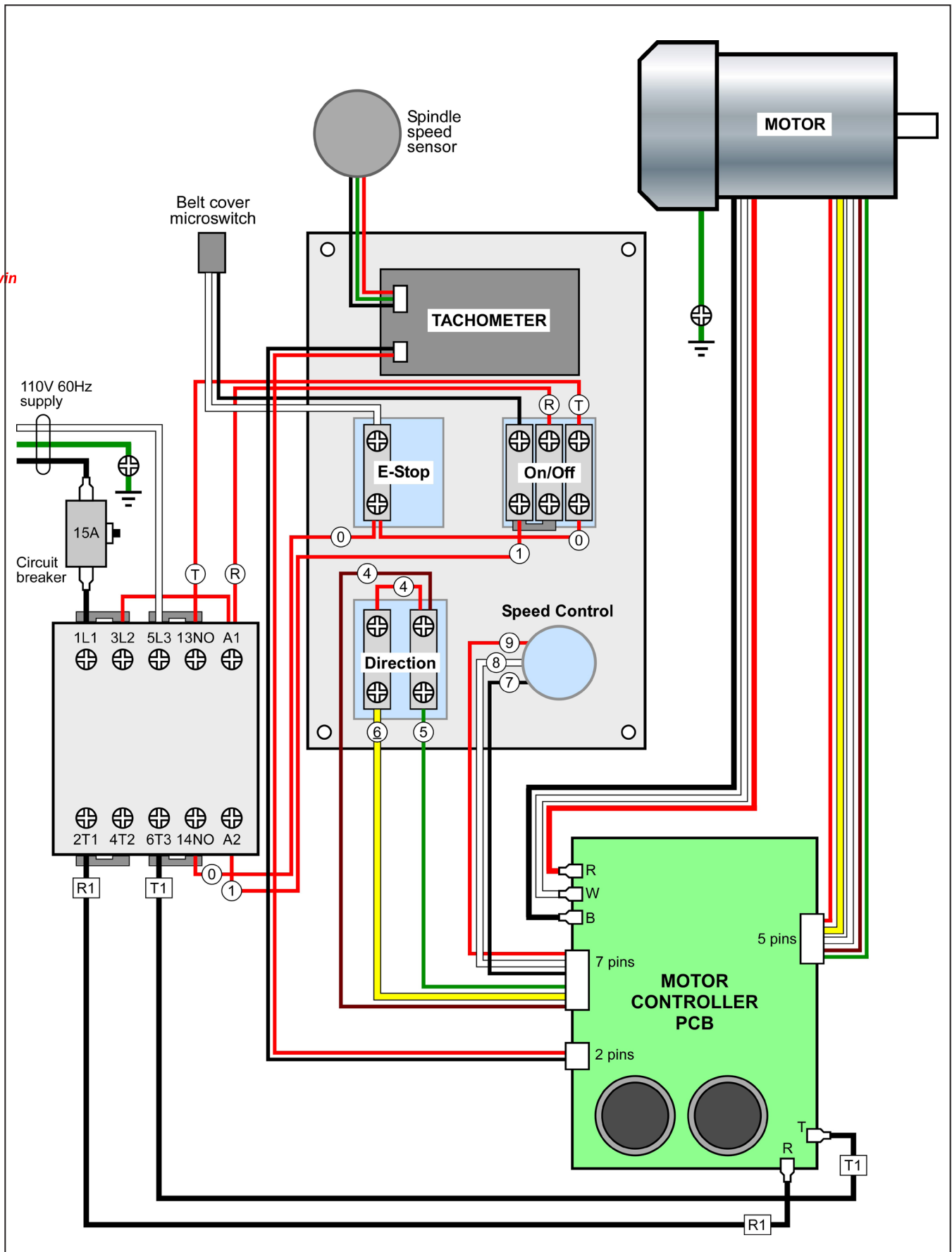
MOTOR CONTROLLER PCB ASSEMBLY



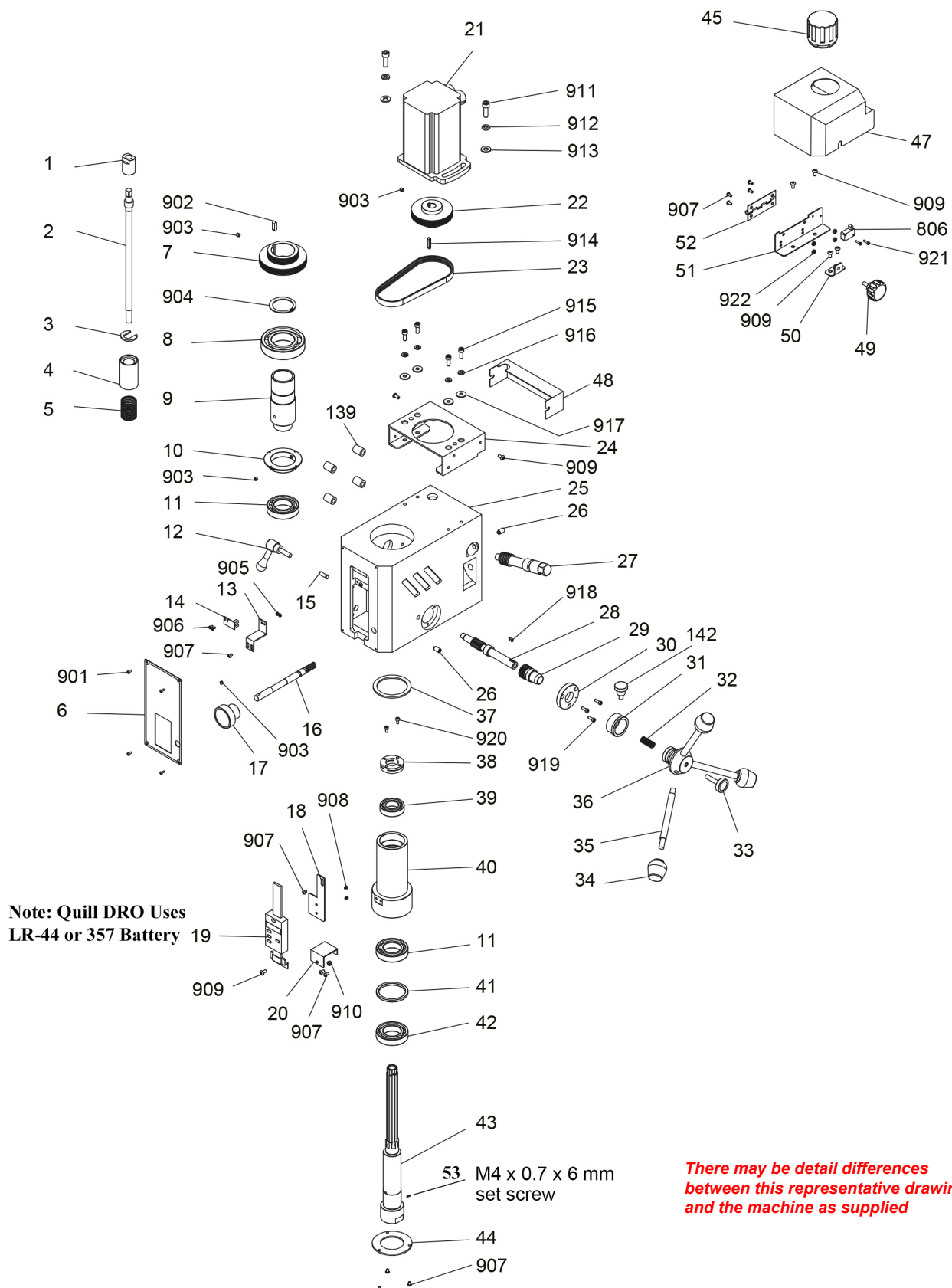
Short beeps	Possible cause	
Series of beeps after pressing stop, or disconnecting power	Powering-down, normal operation	
Two beeps	Low voltage (motor is running)	
Three beeps	Overload	
Four beeps	Over-heating	
Five beeps	Over-voltage	
Six beeps	Over-current	
Seven beeps	EEPROM error	
WARNINGS		
Long beeps	Possible cause	Note
Two beeps	Bus voltage is lower than 250Vdc	F_058=250.0
Three beeps	Output current is higher than 7A	F_056 =7.0
Four beeps	Drive temperature is higher than 80 ° C	F_057=80.0

Model PM-728V-T Electrical Fig 1

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Model PM-728V-T HEADSTOCK & SPINDLE **Fig 2**

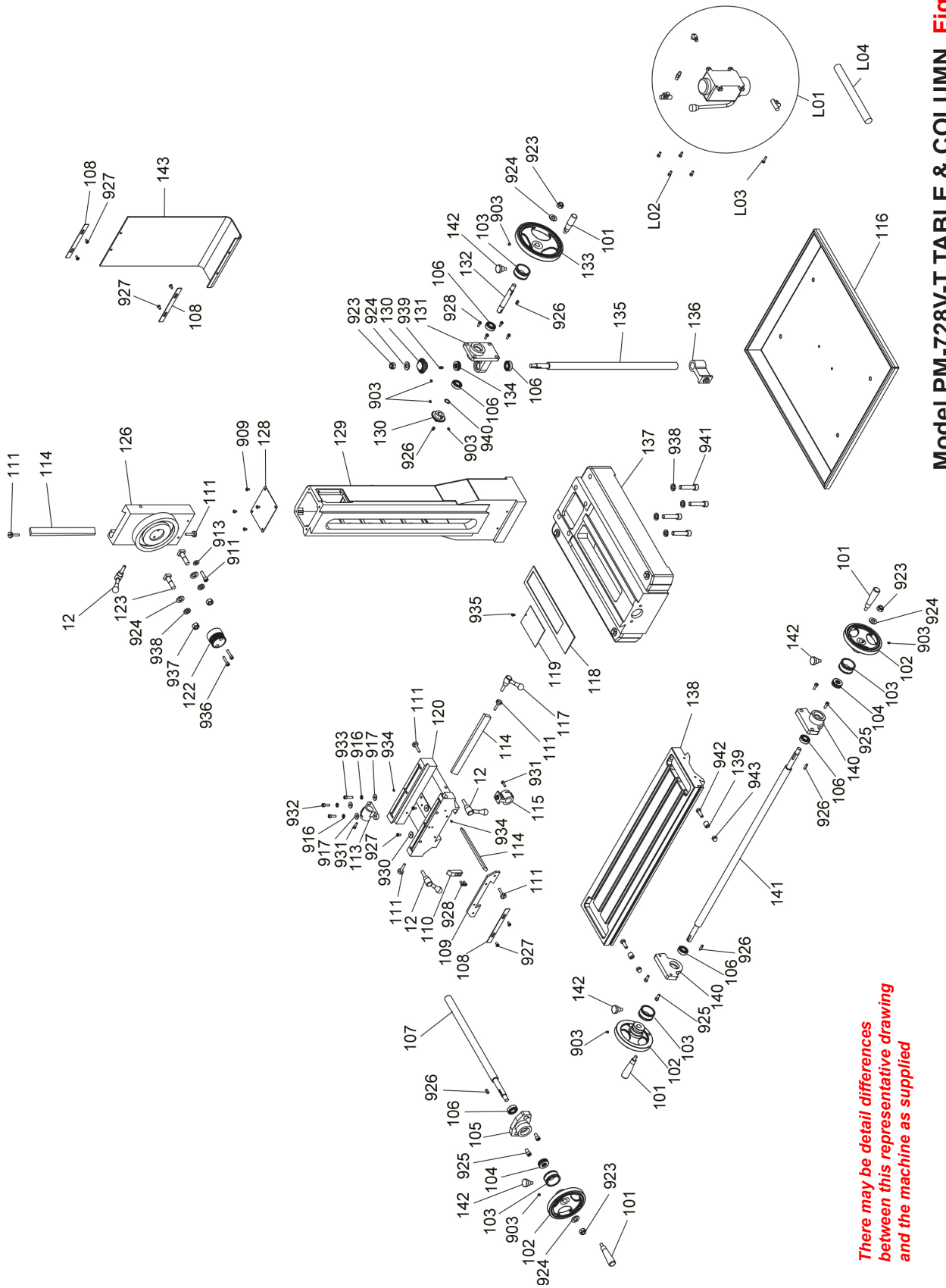


There may be detail differences between this representative drawing and the machine as supplied

Model PM-728V-T HEADSTOCK & SPINDLE Fig 2

Ref	Description	Part
1	Spindle cap	Z5962
2	Draw bar	Z5963
3	C-clip, spring cup retainer	Z5964
4	Return spring cup	Z5965
5	Return spring	Z5966
6	Front plate	Z5967
7	Spindle pulley	Z5968
8	Bearing 6209ZZ	Z5969
9	Spindle sleeve	Z5970
10	Tach disk	Z5971
11	Ball bearing 6007ZZ	Z5972
12	Lock lever	Z5973
13	DRO bracket	Z5974
14	Sensor	Z5975
15	Pin	Z5976
16	Worm shaft	Z5977
17	Knob	Z5978
18	DRO back plate	Z5979
19	DRO assembly	Z5980
20	Scale bracket	Z5981
21	Motor	Z5982
22	Motor pulley	Z5983
23	Belt	Z5984
24	Motor base	Z5985
25	Head casting	Z5986
26	Set screw	Z5987
27	Head tilting worm shaft	Z5988
28	Pinion shaft	Z5989
29	Worm wheel	Z5990
30	Flange	Z5991
31	Dial	Z5992
32	Spring	Z5993
33	Clamp knob	Z5994
34	Lever knob	Z5995
35	Handle lever	Z5996
36	Pinion shaft hub	Z5997
37	O-ring	Z5998
38	Spindle nut	Z5999

Ref	Description	Part
39	Ball bearing 6005ZZ	Z6000
40	Quill	Z6001
41	Bearing spacer	Z6002
42	Ball bearing 7007	Z6003
43	Spindle	Z6004
44	Bearing cover	Z6005
45	Drawbar cover	Z6006
47	Drive cover	Z6007
48	Drive rear cover	Z6008
49	Clamp screw	Z6009
50	Clamp bracket	Z6010
51	Hinge base	Z6011
52	Cover hinge	Z6012
53	Set Screw M4x.7x6	Z7536
806	Microswitch	Z6013
901	Phl. hd. screw	Z6014
902	Key	Z6015
903	Set screw	Z6016
904	Ext. retaining ring	Z6017
905	Nut M3	Z6018
906	Screw	Z6019
907	Cap screw	Z6020
908	Phl. hd. screw	Z6021
909	Cap screw	Z6022
910	Nut	Z6023
911	Cap screw	Z6024
912	Lock washer	Z6025
913	Washer	Z6026
914	Key	Z6027
915	Cap screw	Z6028
916	Lock washer	Z6029
917	Washer	Z6030
918	Key	Z6031
919	Cap screw	Z6032
920	Cap screw	Z6033
921	Phl. hd. screw	Z6034
922	Nut	Z6035



Model PM-728V-T TABLE & COLUMN Fig 3

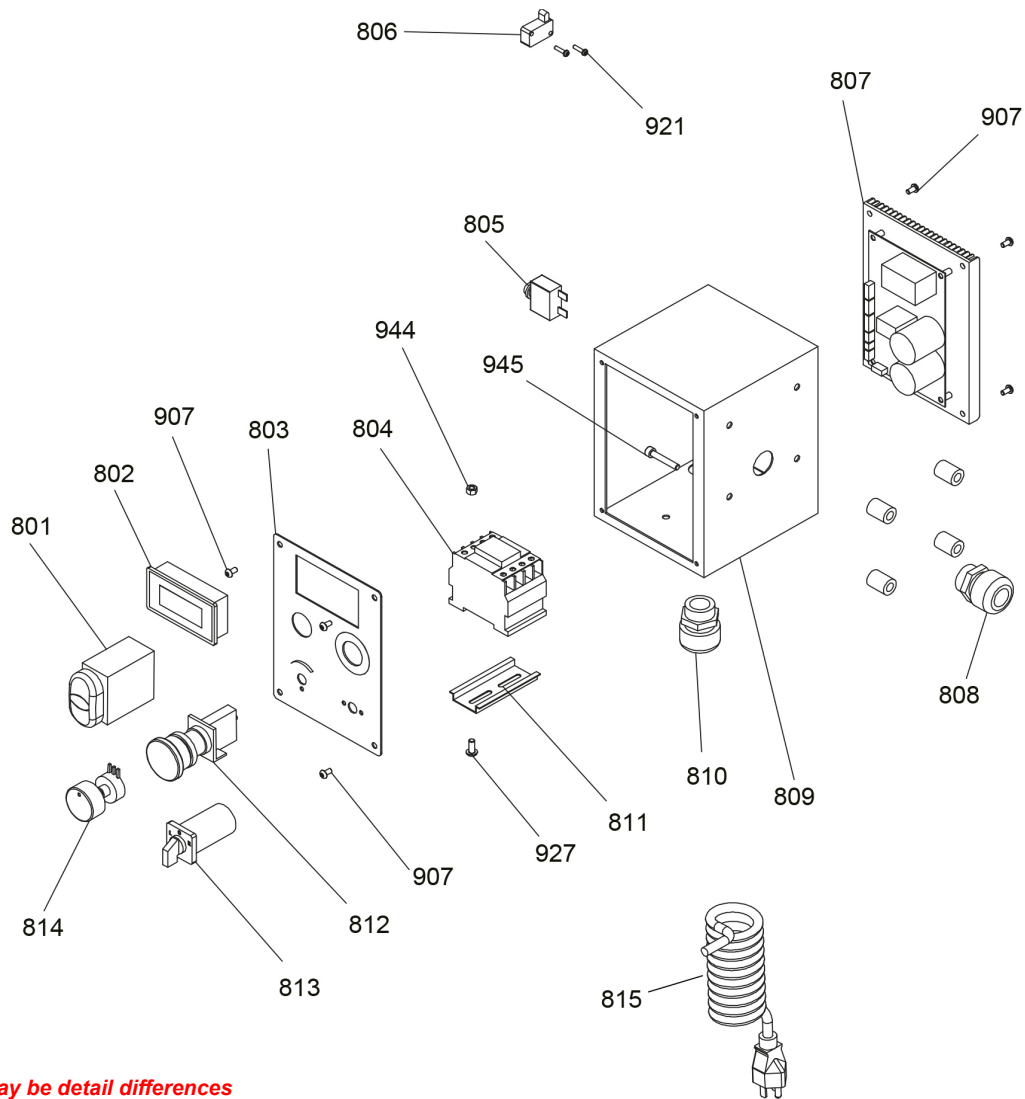
There may be detail differences between this representative drawing and the machine as supplied

Model PM-728V-T TABLE & COLUMN **Fig 3**

Ref	Description	Part
12	Lock lever	Z5973
101	Handle	Z6037
102	Handwheel	Z6038
103	Graduated dial	Z6039
104	Thrust bearing 51202	Z6040
105	Leadscrew flange	Z6041
106	Ball bearing 6002ZZ	Z6042
107	Y-axis lead screw	Z6043
108	Backing plate	Z6044
109	Dovetail guard	Z6045
110	Stop block	Z6046
111	Gib adjustment screw	Z6047
113	X-axis leadscrew nut	Z6048
114	Gib	Z6049
115	Y-axis leadscrew nut	Z6050
116	Chip pan	Z1011
117	Lock lever	Z6052
118	Leadscrew cover A	Z6053
119	Leadscrew cover B	Z6054
120	Saddle	Z6055
122	Head tilt worm wheel	Z6056
123	T-bolt	Z6057
126	Headstock base	Z6058
128	Column cover	Z6059
129	Column	Z6060
130	Bevel gear	Z6061
131	Z-axis gear bracket	Z6062
132	Z-axis crank shaft	Z6063
133	Hand wheel	Z6064
134	Thrust bearing 51102	Z6065
135	Z-axis leadscrew	Z6066
136	Leadscrew nut	Z6067
137	Machine base	Z6068
138	Table	Z6069
139	Movable stop sleeve	Z6070

Ref	Description	Part
140	Leadscrew flange	Z6071
141	X-axis lead screw	Z6072
142	Locking thumb screw	Z6073
143	Way cover	Z6074
903	Set screw	Z6016
909	Cap screw	Z6022
911	Cap screw	Z6024
913	Washer	Z6026
916	Lock washer	Z6029
917	Washer	Z6030
923	Nylon hex nut	Z6081
924	Washer	Z6082
925	Cap screw	Z6083
926	Woodruff key	Z6084
927	Phl. hd. screw	Z6085
928	Cap screw	Z6086
930	Washer	Z6087
931	Cap screw	Z6088
932	Cap screw	Z6089
933	Cap screw	Z6090
934	Set screw	Z6091
935	Cap screw	Z6092
936	Cap screw	Z6093
937	Hex nut	Z6094
938	Lock washer	Z6095
939	Key	Z6096
940	Retaining ring	Z6097
941	Hex hd. bolt	Z6098
942	Cap screw	Z6099
943	Nut	Z6100
L01	One-shot oiler	Z6101
L02	Phl. hd. screw	Z6102
L03	Screw	Z6103
L04	Tubing	Z6104

Model PM-728V-T ELECTRICAL COMPONENTS **Fig 4**



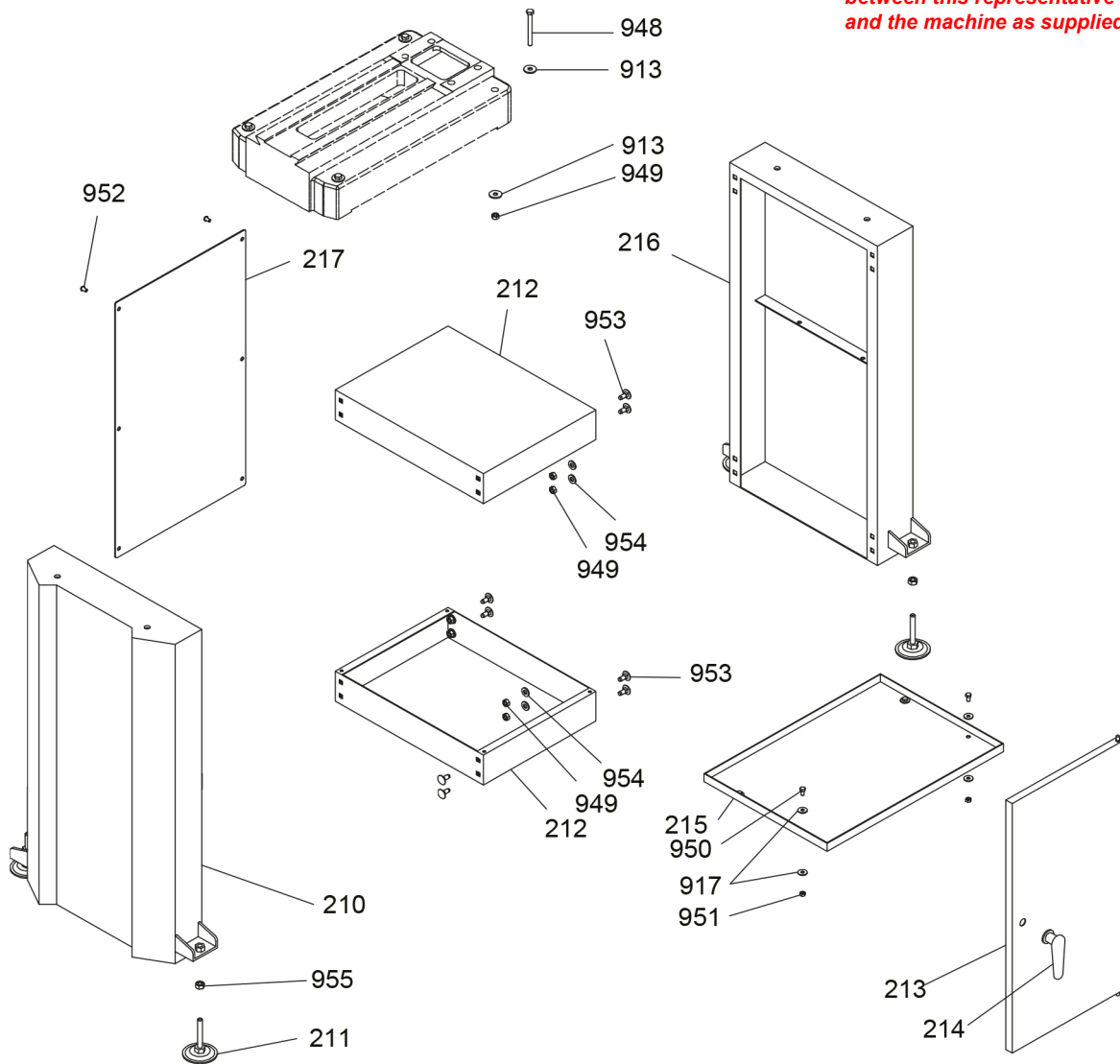
*There may be detail differences
between this representative drawing
and the machine as supplied*

Ref	Description	Part
801	ON/OFF switch	Z6105
802	Tachometer	Z6106
803	Control panel	Z6107
804	Contactor	Z6108
805	Overload Switch	Z6109
806	Limit switch	Z6013
807	Motor Control Board	Z6111
808	Cable bushing	Z6112
809	Electrical box	Z6113

Ref	Description	Part
810	Cable bushing	Z6114
811	Connector mount	Z6115
812	E-stop button	Z6116
813	Fwd/Rev selector switch	Z6117
814	Speed potentiometer	Z6118
815	Power cord	Z6119
907	Cap screw	Z6020
927	Phl. hd. screw	Z6085

Model PM-728V-T STAND Fig 5

*There may be detail differences
between this representative drawing
and the machine as supplied*



Ref	Description	Part
210	Front panel	Z6122
211	Leveling screw	Z6123
212	Top/bottom panel	Z6124
213	Door	Z6125
214	Handle	Z6126
215	Shelf	Z6127
216	Rear panel	Z6128
217	Side panel	Z6129
913	Washer	Z6026

Ref	Description	Part
917	Washer	Z6030
948	Hex screw M8 x 100	Z6132
949	Nut M8	Z6133
950	Hex screw M8 x 20	Z6134
951	Nut M6	Z6135
952	Cap screw	Z6136
953	Carriage screw M8 x 20	Z6137
954	Washer	Z6138
955	Nut 1/2	Z6139